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TECHNOLOGY FOR PRODUCING KERAMZIT FROM LOW EXPANDABLE CLAY

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The possibility of producing low-density, high-strength keramzit from low expandable clay raw material using lignin-alkaline reagent (LAR) is investigated. The particulars of the formation of the porous structure of keramzit granules using different temperature–time regimes and its effect on the physical–mechanical properties of the material are studied.

Key words: keramzit, porosity, strength, expansion ratio, melt, temperature–time interval, structure, lignin-alkaline reagent.

The density of most domestically produced keramzit is 500 – 600 kg/m^3. The production of M75 light concrete, which is the concrete most widely used for erecting barriers with density of the order of 600 – 700 kg/m^3, requires keramzit with density to 350 kg/m^3 with crush strength in a cylinder at least 1.5 MPa (Amendments No. 3 to the Building Code 11-3–79 "Construction heat-engineering" have restricted the use of keramzit grit as a warmer because of its high density). One reason for the degradation of the quality of keramzit grit is the exhaustion of the reserves of domestic high-quality clays and the use of low-grade clay, which in its natural form is incapable of expanding, in production. For this reason, all potential technological possibilities should be used to enhance expansion:

– application of complex additives promoting expansion with ratio less than 3 and the formation of a low-defect cellular structure;

– theoretical and experimental validation of optimal temperature–time regimes for the formation of the structure of keramzit granules with low density and high strength.

The possibility of producing keramzit using Gorodishchenskaya clay from Belgorod Oblast was investigated. The chemical composition of the clay is as follows (%[3]): 69.3 SiO_2, 4.4 Al_2O_3, 4.5 Fe_2O_3, 3.3 RO, 2.04 R_2O, and 0.17 SO_3. The silica content of the clay studied is elevated but the amounts of aluminum and iron oxides and organic impurities are inadequate.

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The suitability of this clay for keramzit production was determined from the optimal ratio of the principal oxide fluxes (see Table 1).

The capability of the raw material to expand was also evaluated according to the ternary diagram SiO_2–Al_2O_3–fluxes. On the basis of its composition Gorodishchenskaya clay is low expandable raw material requiring the use of porophores.

On the basis of its mineralogical composition the clay studied is a montmorillonite–hydromica clay with a small content of the mineral kaolinite. The impurity minerals are represented by quartz, calcite, limonite, and hematite. According to GOST 9169–95 the clay studied is a low-disperse clay (the content of particle smaller than 5 μm > 54%), which is a source of pyroplastic expandable melt.

The temperature interval where the amount of melt increases and the material transitions from a solid into a pyroplastic state is of special interest.

TABLE 1. Optimal Ratio of Individual Oxide Fluxes

Oxide ratios	Values of oxide ratios	
	in Gorodishchenskaya clay	optimal for keramzit clays
Fe_2O_3 : CaO = 4.3 : 2.43	1.8	4.0 – 7.0
$(Fe_2O_3 + MgO + NaO + K_2O)/CaO$	1.5	≥ 4
$RO/(SiO_2 + Al_2O_3)$	0.04	0.04 – 0.13
$Fe_2O_3/(SiO_2 + Al_2O_3)$	0.041	0.04 – 1.12

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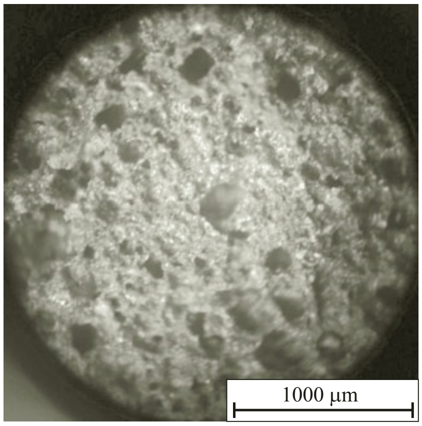

Fig. 1. Granule structure, kilning temperature 1200°C, and soaking time 5 min.

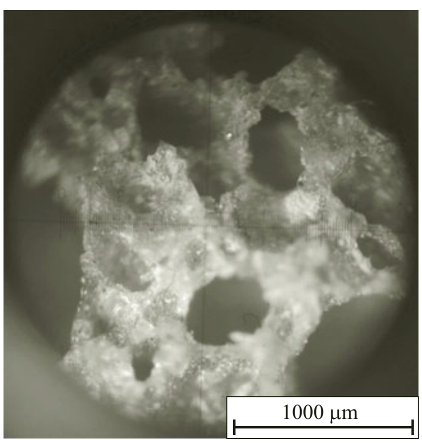

Fig. 2. Granule structure, kilning temperature 1180°C, and soaking time 5 min.

A calculation of the viscosity curve of low-alkaline clay raw materials in the temperature interval 500 – 1000°C by Okhotin's method showed that the transition from a brittle into a pyroplastic state corresponds to temperature 650°C and the transition into the liquid-mobile state corresponds to 1000°C. In the process the viscosity of the melt changed from 10^{12} to 10^6 Pa · sec.

The amount of melt formed was calculated according to the diagrams N – F – S, K – C – S, K – A – S, C – A – S, and N – A – S. By analyzing the diagrams it was possible to determine the melt amount as about 2 – 5% and the temperature interval in which it appears as 850 – 1200°C.

A lignin-alkaline reagent (LAR), which is a processing product from the interaction of lignite and sodium hydroxide NaOH, was used to increase the expandability. The content of sodium salts of humic acids is at least 35%.

The temperature of the onset of the expansion of keramzit with granule density 950 kg/m^3 was determined in the course of the experiment. This temperature was 1100 and 1200°C in the samples with and without LAR, respectively.

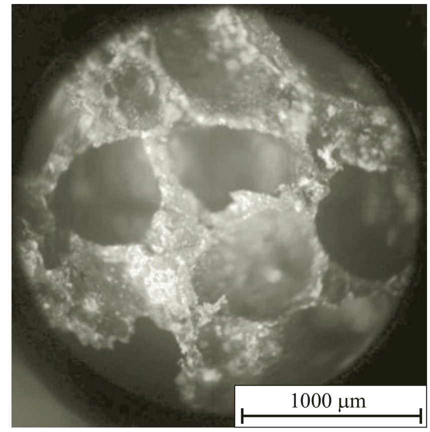

Fig. 3. Granule structure, kilning temperature 1180°C, and soaking time 8 min.

The difference between the maximum possible kilning temperature and the expansion onset temperature of the raw material in these samples was 80 and 100°C, respectively. This determines the practicability of obtaining keramzit under industrial conditions, because the expansion interval for the raw material is at least 50°C.

The optimal temperature–time regime which made it possible to obtain keramzit with density 380 kg/m^3 and expansion ratio 4 was determined experimentally. When kilning granules in the fast regime amorphization of the dehydrated clay material in an oxidative medium started after soaking at 1200°C for 5 min. At this temperature the expandability of the granules is inadequate and the pore size in the granules does not exceed 0.2 mm in the samples (Fig. 1); and the density is 900 kg/m^3. Non-amorphized 0.6 – 0.8 mm thick clayey material is observed in the shell surrounding the granules. As temperature increases to 1300°C the expandability of the melt increases and the pore size increases to 0.4 – 0.6 mm; the density decreases to 500 kg/m^3; the expansion ratio reaches 1.5; the average compression strength of the samples is 3.5 MPa; and, the water absorption is 10%.

A change of the gas medium from oxidizing to reducing as a result of LAR addition affects the temperature–time regime for obtaining low-density keramzit. Melting of the clay material in zones with an oxidizing-reducing medium is observed at kilning temperature 1180°C even with 5-min soaking. Zonality appears in the cross section of the granules. A nonuniform porous structure with 0.07 – 0.2 mm pores (Fig. 2) is formed in the interior volume of the granules; cavity-like pores 1 – 2 mm in size are encountered. The exterior part of the granules is surrounded by a dense shell consisting of non-amorphized clayey material up to 1 mm thick. The density of the granules reaches 700 – 800 kg/m^3; the expansion ratio is 1.5; the compression strength is 5 MPa; and, the water absorption is 10%. Soaking for 8 – 10 min is required to increase expansion and formation of a uniformly porous structure at the given temperature. A cellular structure with predominate pore size 0.6 – 1 mm forms at the center of

the granules in these samples (Fig. 3). Pores to 2 mm are observed. Fine pores 0.015 – 0.07 mm in size are encountered in the 0.015 – 0.07 mm thick interpore space; a fine-pore, dense, 1-mm thick shell, represented by an oxidized glass phase, is observed along the periphery of the granules.

The structural–textural characteristics of the keramzit granules predetermined the following physical–mechanical properties of the keramzit: water absorption 15%; average compression strength of individual granules in press 1.9 MPa; density 380 kg/m^3; and, expansion ratio 4.

In summary, the possibility of obtaining high-quality keramzit from low expandable Gorodishchenskaya clay has been confirmed. This research has shown that the use of lignin-alkaline reagent for expansion of ceramic granules is highly effective, which makes it possible to recommend its use in production.